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CLAIMS

1. A magnetic read head that has an air bearing surface (ABS), a read region that has first and second sides that extend substantially perpendicular to the ABS, first and second end regions that are adjacent said first and second sides respectively and the read region and the first and second end regions being adjacent said ABS, the magnetic read head comprising:

a read sensor located in the read region and having first and second side edges that define said first and second sides of the read region;

said read sensor including:

a ferromagnetic free layer and a ferromagnetic pinned layer; and

an electrically conductive non-magnetic spacer layer sandwiched between the free and pinned layers;

first and second lead layers located in the first and second end regions, each lead layer having a first side edge wherein the first side edge of the first lead layer is adjacent the first side edge of the read sensor and the first side edge of the second lead layer is adjacent the second side edge of the read sensor;

first and second read gap layers wherein each read gap layer is located in the read and first and second end regions;

first and second shield layers;

the read sensor and the first and second read gap layers being sandwiched between the first and second shield layers;

the first read gap layer comprising a bi-layer of an insulation film and an antiferromagnetic oxide film sandwiched between the first shield layer and the first lead layer in the first end region, sandwiched between the first shield layer and the read sensor

in the read region and sandwiched between the first shield layer and the second lead layer in the second end region;

the free layer being located between the antiferromagnetic oxide film and the pinned layer; and

the first and second lead layers exchange coupling to the antiferromagnetic oxide film and magnetostatically coupling to the read sensor.

2. A magnetic read head as claimed in claim 1 wherein the read sensor further includes:

an antiferromagnetic metallic layer exchange coupling to the pinned layer; and

a non-magnetic layer sandwiched between the free layer and the antiferromagnetic oxide film in the read region.

3. A magnetic read head as claimed in claim 2 including:

each of the first and second lead layers having a ferromagnetic film; and

the ferromagnetic film of each of the first and second lead layers exchange coupling to the antiferromagnetic oxide film in the first and second end regions respectively and magnetostatically coupling to the read sensor.

4. A magnetic read head as claimed in claim 3 wherein each lead layer includes:

non-magnetic adhesion and cap films;

an electrically conductive non-magnetic film sandwiched between the non-magnetic adhesion and cap films; and

in each of the first and second lead layers, the ferromagnetic film being sandwiched between the antiferromagnetic oxide film and the adhesion film in the first and second end regions.

5. A magnetic read head as claimed in claim 4 wherein the antiferromagnetic metallic layer is selected from the group Ir-Mn, Ni-Mn, Rh-Mn, Pt-Mn, Pd-Pt-Mn and Cr-Pt-Mn.

6. A magnetic read head as claimed in claim 4 wherein the antiferromagnetic oxide film is selected from the group NiO and α-Fe_2O_3.

7. A magnetic read head as claimed in claim 4 wherein the antiferromagnetic metallic layer is selected from the group Ir-Mn, Ni-Mn, Rh-Mn, Pt-Mn, Pd-Pt-Mn and Cr-Pt-Mn.

8. A magnetic read head as claimed in claim 4 wherein the non-magnetic seed layer is Ta, the free layer is Ni-Fe, the spacer layer is Cu, the pinned layer is Co and the antiferromagnetic metallic layer is Ni-Mn.

9. A magnetic read head as claimed in claim 8 wherein the antiferromagnetic oxide film is selected from the group NiO and α-Fe_2O_3.

10. A magnetic read head as claimed in claim 4 wherein the antiferromagnetic oxide film is NiO and the ferromagnetic film of each of the first and second lead layers is Ni-Fe.

11. A magnetic read head as claimed in claim 4 wherein the second gap layer interfacially engages the antiferromagnetic metallic film.

12. A magnetic read head as claimed in claim 11 wherein the antiferromagnetic metallic layer is Ni-Mn.

13. A magnetic read head as claimed in claim 12 wherein a thickness of the antiferromagnetic metallic film is 15 - 25 nm.

14. A magnetic read head as claimed in claim 13 wherein the antiferromagnetic oxide film is NiO and the ferromagnetic film of each of the first and second lead layers is Ni-Fe.

15. A merged magnetic head that has a read head and a write head wherein each head forms a portion of an air bearing surface (ABS) comprising:

said read head including:

a read region that has first and second sides that extend substantially perpendicular to the ABS, first and second end regions that are adjacent said first and second sides respectively and the read region and first and second end regions being adjacent said ABS;

a read sensor located in the read region and having first and second side edges that define said first and second sides of the read region;

said read sensor including:

a ferromagnetic free layer and a ferromagnetic pinned layer; and

an electrically conductive non-magnetic spacer layer sandwiched between the free and pinned layers;

first and second lead layers located in the first and second end regions, each lead layer having a first side edge wherein the first side edge of the first lead layer is adjacent the first side edge of the read sensor and the first side edge of the second lead layer is adjacent the second side edge of the read sensor;

first and second gap layers wherein each gap layer is located in the read and first and second end regions;

the read sensor and the first and second gap layers being sandwiched between the first and second shield layers;

the first read gap layer comprising a bi-layer of an insulation film and an antiferromagnetic oxide film sandwiched between the first shield layer and the first lead layer in the first end region, sandwiched between the first shield layer and the read sensor in the read region and sandwiched between the first shield layer and the second lead layer in the second end region;

the free layer being located between the antiferromagnetic oxide film and the pinned layer; and

the first and second lead layers exchange coupling to the antiferromagnetic oxide film and magnetostatically coupling the read sensor; and said write head including:

first and second pole piece layers wherein the first pole piece layer is a common layer with said second shield layer;

a write gap layer;

the first and second pole piece layers being separated by the write gap layer at the ABS and connected together at a back gap;

an insulation stack with at least one coil layer embedded therein; and

the insulation stack being sandwiched between the first and second pole piece layers and being located between the ABS and said back gap.

16. A merged magnetic head as claimed in claim 15 comprising:

the read sensor including:

an antiferromagnetic metallic layer exchange coupling to the pinned layer; and

a non-magnetic layer sandwiched between the free layer and the antiferromagnetic oxide film in the read region;

each of the first and second lead layers having a ferromagnetic film;

the ferromagnetic film of each of the first and second lead layers exchange coupling to the antiferromagnetic oxide film in the first and second end regions respectively and magnetostatically coupling to the read sensor;

a non-magnetic adhesion film and cap film;

an electrically conductive non-magnetic film sandwiched between non-magnetic adhesion and cap films; and

in each of the first and second lead layers, the ferromagnetic film being sandwiched between the non-magnetic adhesion film and the antiferromagnetic oxide film in the first and second end regions.

17. A merged magnetic head as claimed in claim 16 wherein the antiferromagnetic oxide film is selected from the group NiO and α-Fe_2O_3.

18. A merged magnetic head as claimed in claim 17 wherein the antiferromagnetic metallic layer is selected from the group Ir-Mn, Ni-Mn, Rh-Mn, Pt-Mn, Pd-Pt-Mn and Cr-Pt-Mn.

19. A merged magnetic head as claimed in claim 16 wherein:

the antiferromagnetic metallic layer is Ni-Mn and is interfacially engaged by the second gap layer.

20. A merged magnetic head as claimed in claim 19 wherein:

a thickness of the antiferromagnetic metallic layer is 15 - 25 nm; and

the antiferromagnetic oxide film is NiO and the ferromagnetic film of each of the first and second lead layers is Ni-Fe.

21. A magnetic disk drive that includes at least one merged magnetic head that has an air bearing surface (ABS), the disk drive comprising:

the merged magnetic head having a write head portion that includes:

a read region that has first and second sides that extend substantially perpendicular to the ABS, first and second end regions that are adjacent said first and second sides respectively and the read region and first and second end regions being adjacent said ABS;

a read sensor located in the read region and having first and second side edges that define said first and second sides of the read region;

said read sensor including:

a ferromagnetic free layer and a ferromagnetic pinned layer;

an electrically conductive non-magnetic spacer layer sandwiched between the free and pinned layers;

first and second lead layers located in the first and second end regions, each lead layer having a first side edge wherein the first side edge of the first lead layer is adjacent the first side edge of the read sensor and the first side edge of the second lead layer is adjacent the second side edge of the read sensor;

first and second gap layers wherein each gap layer is located in the read and first and second end regions;

the read sensor and the first and second gap layers being sandwiched between the first and second shield layers;

the first read gap layer comprising a bi-layer of an insulation film and an antiferromagnetic oxide film sandwiched between the first shield layer and the first lead layer in the first end region, sandwiched between the first shield layer and the read sensor in the read region and sandwiched between the first shield layer and the second lead layer in the second end region;

the free layer being located between the antiferromagnetic oxide film and the pinned layer; and

the first and second lead layers exchange coupling to the antiferromagnetic oxide film and magnetostatically coupling to the read sensor; and

the merged magnetic head having a write head portion that includes:

first and second pole piece layers wherein the first pole piece layer is a common layer with said second shield layer;

a write gap layer;

the first and second pole piece layers being separated by the write gap layer at the ABS and connected together at a back gap;

an insulation stack with at least one coil layer embedded therein; and

the insulation stack being sandwiched between the first and second pole piece layers and being located between the ABS and said back gap;

a frame;

a magnetic disk rotatably supported on the frame;

a support mounted on the frame for supporting the merged magnetic head in a transducing relationship with the magnetic disk;

means for rotating the magnetic disk;

positioning means connected to the support for moving the merged magnetic head to multiple positions with respect to said magnetic disk; and

means connected to the merged magnetic head, to the means for rotating the magnetic disk and to the positioning means for exchanging signals with the merged magnetic head, for controlling movement of the magnetic disk and for controlling the position of the merged magnetic head.

22. The magnetic disk drive as claimed in claim 21, comprising:

the read sensor including:

an antiferromagnetic metallic layer exchange coupling to the pinned layer; and

an electrically conductive non-magnetic layer sandwiched between the free layer and the antiferromagnetic oxide film in the read region;

each of the first and second lead layers having a ferromagnetic film; and

the ferromagnetic film of each of the first and second lead layers exchange coupling to the antiferromagnetic oxide film in the first and second end regions respectively and magnetostatically coupling to the read sensor;

wherein each lead layer includes:

a non-magnetic adhesion film and a cap film;

an electrically conductive film sandwiched between the non-magnetic adhesion and cap films; and

in each of the first and second lead layers, the ferromagnetic film being sandwiched between the non-magnetic adhesion film and the antiferromagnetic oxide film in the first and second end regions.

23. A method of making a magnetic read head wherein the read head has a read region that has first and second sides that extend substantially perpendicular to the ABS, first and second end regions that are adjacent the first and second sides respectively and the read region and first and second end regions being adjacent the ABS, comprising:

forming a first shield layer;

forming an insulation layer on the first shield layer;

forming an antiferromagnetic oxide film on the insulation film;

forming a spin valve sensor with a non-magnetic layer directly on a first gap layer, the first gap layer comprising a bi-layer of said insulation film and said antiferromagnetic oxide film;

forming a mask on the spin valve sensor with first and second openings at first and second lead layer sites wherein the first and second openings define first and second side edges of a spin valve sensor to be located in the read region;

milling away spin valve sensor material in the first and second openings to expose the antiferromagnetic oxide film;

forming first and second lead layers on the antiferromagnetic oxide film in the first and second openings;

removing the mask;

forming a second gap layer on the spin valve sensor and the first and second lead layers; and

forming a second shield layer on the second gap layer.

24. A method as claimed in claim 23 wherein the first and second lead layers have a ferromagnetic film formed directly on the antiferromagnetic oxide film in the first and second end regions respectively.

25. A method as claimed in claim 24 wherein the spin valve sensor is formed in the presence of a magnetic field that is directed perpendicular to the ABS and the first and second lead layers are formed in the presence of a magnetic field that is directed parallel to the ABS.

26. A method of making a magnetic read head wherein the read head has a read region that has first and second sides that extend substantially perpendicular to the ABS, first and second end regions that are adjacent the first and second sides respectively and the read region and first and second end regions being adjacent the ABS, comprising:

forming a first shield layer;

forming an insulation film on the first shield layer;

forming an antiferromagnetic oxide film on the insulation film;

forming a spin valve sensor on a first read gap layer which comprises bi-layer of said insulation film and said antiferromagnetic oxide film;

said forming of the spin valve sensor including:

forming a non-magnetic seed layer directly on the antiferromagnetic oxide film;

forming a ferromagnetic free layer on the non-magnetic seed layer;

forming a electrically conductive non-magnetic spacer layer on the free layer;

forming a ferromagnetic pinned layer on the electrically conductive non-magnetic spacer layer;

forming an antiferromagnetic metallic layer of Ni-Mn on the ferromagnetic pinned layer;

forming a cap layer on the antiferromagnetic metallic layer;

annealing the ferromagnetic pinned layer and the antiferromagnetic metallic layer of Ni-Mn at 240°-280° for 2-10 hours in a field that is directed transverse to the ABS;

forming a mask with first and second openings at the first and second end regions wherein the first and second openings define said first and second sides of the read region;

milling away the spin valve sensor within each of the first and second openings to expose the antiferromagnetic oxide film;

forming first and second lead layers on the antiferromagnetic oxide film in the first and second openings respectively; and

removing the mark;

milling away the cap layer and a portion of the antiferromagnetic metallic layer of the spin valve sensor and a portion of the cap layer of the first and second lead layers;

forming a second read gap layer on the antiferromagnetic metallic layer and on the first and second lead layers; and

forming a second shield layer on the second read gap layer.

27. A method as claimed in claim 26 wherein the antiferromagnetic oxide film is NiO.

28. A method as claimed in claim 27 wherein the forming each of the first and second lead layers comprises:

forming a soft ferromagnetic film directly on the antiferromagnetic oxide film portion in a respective end region;

forming a non-magnetic adhesion film on a respective soft ferromagnetic film in a respective end region;

forming an electrically conductive non-magnetic film on a respective non-magnetic adhesion film in a respective end region; and

forming a non-magnetic cap layer on a respective electrically conductive non-magnetic film in a respective end region.

29. A method as claimed in claim 28 wherein the first and second lead layers are formed in the presence of a field that is directed parallel to the ABS.

30. A method of making a magnetic read head that has an air bearing surface (ABS), a read region that has first and second sides that extend substantially perpendicular to the ABS, first and second end regions that are adjacent the first and second sides respectively and the read region and first and second end regions being adjacent the ABS, comprising:

forming a read sensor in the read region with first and second side edges that define said first and second sides of the read region as follows:

forming a ferromagnetic free layer and a ferromagnetic pinned layer;

forming an electrically conductive non-magnetic spacer layer between the free and pinned layers;

forming an antiferromagnetic metallic layer that exchange couples to the pinned layer; and

forming a cap layer, on the antiferromagnetic metallic layer;

forming first and second lead layers in the first and second end regions with each lead layer having a first side edge wherein the first side edge of the first lead layer is adjacent the first side edge of the read sensor and the first side edge of the second lead layer is adjacent the second side edge of the read sensor;

forming first and second gap layers with each gap layer located in each of the read and first and second end regions;

forming the read sensor and the first and second gap layers between the first and second shield layers;

forming an antiferromagnetic oxide film between an insulation film and the first lead layer in the first end region, between the insulation film and the read sensor in the read region and between the insulation film and the second lead layer in the second end

region with the first and second lead layers being exchange coupling to the antiferromagnetic oxide film and magnetostatically coupling to the read sensor; and

the forming of the read sensor locating the free layer between the antiferromagnetic oxide film and the pinned layer

31. A method as claimed in claim 30 including:

forming each of the first and second lead layers with a ferromagnetic film so that the ferromagnetic film of each of the first and second lead layers exchange couples to the antiferromagnetic oxide film in the first and second end regions respectively and magnetostatically couples the read sensor.

32. A method as claimed in claim 31 wherein the making of each lead layer includes:

forming non-magnetic adhesion and cap films;

forming an electrically conductive non-magnetic film between the non-magnetic adhesion and cap films; and

in each of the first and second lead layers, forming the ferromagnetic film between the non-magnetic adhesion film and the antiferromagnetic oxide film in the first and second end regions, respectively.

33. A method as claimed in claim 32 wherein the antiferromagnetic metallic layer is selected from the group Ir-Mn, Ni-Mn, Rh-Mn, Pt-Mn, Pd-Pt-Mn and Cr-Pt-Mn.

34. A method as claimed in claim 32 wherein the antiferromagnetic oxide film is selected from the group NiO and α-Fe_2O_3.

35. A method as claimed in claim 34 wherein the antiferromagnetic metallic layer is selected from the group Ir-Mn, Ni-Mn, Rh-Mn, Pt-Mn, Pd-Pt-Mn and Cr-Pt-Mn.

36. A method as claimed in claim 32 wherein the non-magnetic seed layer is Ta, the free film is Ni-Fe, the spacer layer is Cu, the pinned layer is Co and the antiferromagnetic metallic layer is Ni-Mn.

37. A method as claimed in claim 36 wherein the antiferromagnetic oxide film is selected from the group NiO and α-Fe_2O_3.

38. A method as claimed in claim 32 wherein the antiferromagnetic oxide film is NiO and the ferromagnetic film of each of the first and second lead layers is Ni-Fe.

39. A method as claimed in claim 32 wherein the second gap layer interfacially engages the antiferromagnetic metallic layer.

40. A method as claimed in claim 39 wherein the antiferromagnetic metallic layer is Ni-Mn.

41. A method as claimed in claim 40 wherein a thickness of the metallic antiferromagnetic layer is 15 - 25 nm.

42. A method as claimed in claim 41 wherein the antiferromagnetic oxide film is NiO and the ferromagnetic film of each of the first and second lead layers is Ni-Fe.

43. A method of making a merged magnetic head that has a read head and a write head wherein each head forms a portion of an air bearing surface (ABS) and the read head has a read region that has first and second sides that extend substantially perpendicular to the ABS, first and second end regions that are adjacent the first and second sides respectively and the read region and first and second end regions being adjacent the ABS, comprising:

making the read head as follows:

forming a multi-layered read sensor in the read region with first and second side edges that define said first and second sides of the read region, and with one of its layers being a non-magnetic layer;

forming first and second lead layers in the first and second end regions with each lead layer having a first side edge wherein the first side edge of the first lead layer is adjacent the first side edge of the read sensor and the first side edge of the second lead layer is adjacent the second side edge of the read sensor;

forming first and second insulation gap layers with each insulation gap layer located in each of the read and first and second end regions;

forming the read sensor and the first and second insulation gap layers between the first and second shield layers; and

forming an antiferromagnetic oxide film between the first insulation gap layer film and the first lead layer in the first end region, between the first insulation gap layer and the read sensor in the read region and between the first insulation gap layer and the second lead layer in the second end region with the first and second lead layers exchange coupling to the antiferromagnetic oxide film and magnetostatically coupling to the first and second side edges respectively of the read sensor; and

the forming of the read sensor forming the non-magnetic layer directly on the antiferromagnetic oxide film;

making the write head as follows:

employing the second shield layer as a first pole piece layer;

forming a second pole piece layer;

forming a write gap layer that separates the first and second pole pieces at the ABS;

connecting the first and second pole piece layers at a back gap;

forming an insulation stack with at least one coil layer embedded therein between the first and second pole piece layers and between the ABS and said back gap.

44. A method as claimed in claim 43 comprising:

making a read head as follows:

forming a ferromagnetic free layer and a ferromagnetic pinned layer;

forming an electrically conductive non-magnetic spacer layer between the free and pinned layers;

forming an antiferromagnetic metallic layer that exchange couples to the pinned layer; and

forming a cap layer;

forming each of the first and second lead layers with a ferromagnetic film so that the ferromagnetic film of each of the first and second lead layers exchange couples to the antiferromagnetic oxide film in the first and second end regions respectively and magnetostatically couples to the first and second side edges respectively of the read sensor;

forming non-magnetic adhesion and cap films;

forming an electrically conductive non-magnetic film between the non-magnetic adhesion and cap films; and

in each of the first and second lead layers, forming the ferromagnetic film between the non-magnetic adhesion film and the antiferromagnetic oxide film.

45. A method as claimed in claim 44 wherein the antiferromagnetic oxide film is selected from the group NiO and α-Fe_2O_3.

46. A method as claimed in claim 45 wherein the antiferromagnetic metallic layer is selected from the group Ir-Mn, Ni-Mn, Rh-Mn, Pt-Mn, Pd-Pt-Mn and Cr-Pt-Mn.

47. A method as claimed in claim 44 wherein:

the second gap layer interfacially engages the antiferromagnetic metallic layer; and

the antiferromagnetic metallic layer is Ni-Mn.

48. A method as claimed in claim 47 wherein:

a thickness of the antiferromagnetic metallic layer is 15 - 25 nm; and

the antiferromagnetic oxide film is NiO and the ferromagnetic film of each of the first and second lead layers is Ni-Fe.

49. A spin valve (SV) sensor having end regions separated from each other by a central region, comprising:

an SV element located in the central region, and having a magnetic pinned layer;

first and second lead layers located in the first and second end regions; and

a continuous antiferromagnetic oxide layer located in the end region and the central region;

the element and first and second lead layers being located over the antiferromagnetic oxide layer, and the pinned layer being separated from the antiferromagnetic oxide layer by a non-magnetic spacer layer.

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